Viral Life, at Last

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> Functioning as re re real antiontology, viral amnesia machinically realizes and dissolves biological […] cultural, and technical 010110100100 […] mnemic structures: chopping-up hierarchic-generational descendency, collapsing phylogenetic tic frozen-code into ontogeny, and immanentizing the past to operative current.
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> —Nick Land, 'Hypervirus', 2011.

Bootstrapping Virality

'Go Viral!' says the cover of the latest issue of the UK edition of *Wired* (Feburary, 2014) that I picked up at Montreal airport on my way to Tokyo to attend the 'Life under Influence' seminar. Inside was a five-page long article on Buzzfeed, the 'viral lab' that 'mastered social sharing (and GIFs and kittens) to become a media giant for a new era' (Rowan 2014). But within the article, I could not find any mention of the word 'virus'—much less a definition of this entity—only its adjective form repeated over and over, and a mere reference to 'memes', the word that Richard Dawkins coined 40 years ago to refer to 'mind viruses' (Dawkins 1989 [1976]). Think *Grumpy cat*. But this, I am afraid, will not help me make my point here.

Instead, I will rather react to the opportunity offered by the *problématisation* of the seminar of the concept of life itself, and offer a way to start answering its central question: 'do we need another concept of life and of living beings?' My perspective will be informed by some recent developments both in biology and computing, i.e. by the two main contemporary becomings of cybernetics. I will argue that we indeed need another concept of life *and* that it is already at work in these cybernetic becomings. From a renewed conception of what a virus—as both life form and form of life—can be, to a renewed conception of their evolutionary role, once the threshold between the analog and the digital, between carbon-based and silicon-based life, has been crossed, I will offer this working hypothesis: 'can we consider life at the level of code itself, and see the symbiotic exchanges of code as the engine of this elusive new conception of life?'

But to begin, let me state that we still do not know what life is—in spite of a score of books with this very question for a title. Since Schrödinger's inaugural essay in 1944: *What is life?*, J.B.S. Haldane published his in 1947, and Lynn Margulis and her son Dorion Sagan in 1995. That same year, Michael P. Murphy and Luke A. J. O'Neill edited a book with the subtitle *The next fifty years: speculations on the future of biology* and in 2002, Douglas Dix added a reflection on the 'Prerequisites for a definition' in *The Yale Journal of Biology and Medicine*; in 2008 Ed Regis went with *Investigating the nature of life in the age of synthetic biology*. Eventually, in 2012, Craig Venter added 'A 21st century perspective'.

Moreover, some might even argue that this very question—'what is life?'—actually does not make sense anymore. In 2011, Stefan Helmreich made this point in a seminal paper. 'A gathering consensus in anthropology, science studies, and philosophy of biology', he wrote in his first sentence, 'suggests that the theoretical object of biology, "life", is today in transformation, if not dissolution' (2011: 671). And his conclusion was even clearer:

> The three biologies I have presented make explicit the instability of 'life' in such other domains as reproductive technology, biodiversity, and biosecurity. The very appearance of the word *life* in quotation marks—in this essay, but also in many of the sources I cite—indicates a social dissensus about its meaning […] In the examples I have offered here, form becomes the shadow of life, only to outgrow it—at the same time as biologists continue to try to recapture it […] What is the shadow of life? The first-draft answer would of course be death—and a good case could be made that today's biopolitics are ever more entangled with necropolitics. But this is not quite right, since the better question is: what can we see in the shadow of life's limit? Answer: the absence of a theory for biology; reaching the limit of life reveals what was there all along, that there is no once and for all theoretical grounding for life. (694–5)

One might then conclude, after Helmreich, that there is no answer to what 'life' might actually be to be found in theory. So, in agreement with my cybercultural opening, I decided to ask the most influential answer-providing engine today: Google™. Here is what the oracle answered. First, it confirmed my intuition since 'Life is a problem' scored 99,900,000 hits, by far the most any queries I tried returned that day. So I resumed entering attempts to define life in one formula, and here are the results (in decreasing scores in hits):

'Life is a chance'	92,300,000
'Life is a gift'	59,700,000
'Life is a process'	28,100,000
'Life is a product'	27,600,000
'Life is a challenge'	26,100,000
'Life is a solution'	22,900,000
'Life is a disease'	9,920,000
'Life is change'	2,860,000
'Life is shit'	2,270,000
'Life is a dream'	926,000
'Life is a journey'	902,000
'Life is a game'	319,000
'Life is code'	16,400
Hence: '*Life is paradoxical*'	68,700

Why, paradoxical? Well the conclusion was obvious, since 'Life is' scored 71,700,000 hits (and the mere word 'Life' 1,480,000,000 hits). Life, indeed, must be paradoxical according to Google, if 'Life is a problem' returned a good 20 million *more* hits than the apparently simpler 'Life is' (explain this, you mighty engine!). To keep up with this paradoxical stance, I thus propose to reflect here on 'viral life', quite a paradoxical expression for quite a paradoxical entity. In fact, in the remainder of the present paper, I will develop the paradoxical status of the virus with regard to life at three intertwined levels: (1) at the level of life/death itself; (2) at the level of a potential opposition, or not, of life forms and forms of life (more later on this distinction); and (3) at the level of the substratum or modalities of life itself, in tension between carbon and silicate, or in other words, in between analog and digital life (whatever that is). I intend to develop these points, *n'en déplaise à mon épigraphe*, as an ontological point, or better said, as an ontogenetic argument. 'The virus' here is no metaphor, and even less a set of metaphors, where the biological virus (analog) would stand for the computer virus (digital), or vice versa. 'Natural' life form and 'artificial'—fabricated or programmed—form of life, the virus is *both*, and thus ideally—because ontogenetically—located at the critical point between nature and culture, an actual entity where their convergence manifests itself. So let me introduce the virus…

The First Convergent Entity

It was in 1981 that Elk Cloner, the first computer virus in the wild (i.e. affecting PCs), was documented, although *Wikipedia* informs us that there were programs analog to what we now call 'viruses' during the 1970s: *Creeper*, on PDP-10/TENEX in 1971, *Rabbit* or *Wabbit*, in 1974, and ANIMAL on Univac 1108 in 1975 (Wikipedia, entry 'Timeline of computer viruses and worms'). Elk Cloner predated the experimental work that 'officially' defined computer viruses and spread on Apple II. When infected, the monitor of the computer displayed the following rhyme: 'It will get on all your disks / It will infiltrate your chips / Yes it's Cloner! / It will stick to you like glue / It will modify ram too / Send in the Cloner!'

Two years later, on November 3, 1983 the first 'official' computer virus was conceived of as an experiment to be presented at a weekly seminar on computer security. Fred Cohen first introduced the concept in this seminar, and his PhD supervisor, Len Adleman, proposed the name 'virus'. In his presentation, Cohen defined a computer virus as 'a computer program that can affect other computer programs by modifying them in such a way as to include a (possibly evolved) copy of itself', a definition he would stick to in his subsequent paper (Cohen 1984), and one that would become the official definition of a 'computer virus'. Cohen produces such an 'infection' within a Unix directory-listing utility, proving that identifying and isolating computer viruses is a non-computable problem. This later result, maybe the most crucial point in Cohen's work, meant that fighting the infection was therefore impossible to achieve using an algorithm.

According to Cohen, the first use of the term virus to refer to an unwanted computer code occurred in David Gerrold's 1972 science fiction novel, *When HARLIE was one*. In an interview, Len Adleman concurred with Cohen: 'The term "computer virus" existed in science fiction well before Fred Cohen and I came along. Several authors actually used that term in science fiction prior to 1983. I don't recall ever having seen it, perhaps it was just a term whose time had come. So I did not invent the term. I just named what we now consider computer viruses "computer viruses"' (Krieger 1996). Indeed, it was a term whose time had come!

So, sometime between 1971 and 1983, the virus turned digital, in science fiction and computer code. In 1992, 1300 computer viruses were recorded, an increase of 420% from December 1990. By November 1990, one new virus was discovered each week. At the beginning of the millennium, between 10 and 15 new viruses appeared every day. From December 1998 to October 1999, the total virus count jumped from 20,500 to 42,000. Today, the latest reports detect 200,000 new malicious programs per day (Kaspersky lab 2012). Viruses have

temporarily lost their title as the most pervasive forms of cyber attacks: in 2012, they amounted to approximately 8% of the causes of the 1.5 billion web-based attacks and more than 3 billion infected files that were detected. This figure, however, can be understood as a sign of their 'comeback': a year later, Tim Rains wrote on the *Microsoft Security Blog* 'The relative prevalence of viruses has been trending up […] Viruses simply didn't support the profit motive many attackers had in the same way that Trojan downloaders and droppers, miscellaneous Trojans, and password stealers and monitoring tools all did'. But, as another analyst put it, 'new threats are sparking a comeback' (Rains 2013).

This spectacular progression, and the parallel genealogy and epidemiology of the scariest (retro)virus of all—HIV, of course—led me to diagnose in 2005 the double nature of this troubling entity and hence emphatically conclude that the virus was indeed the first convergent entity according to codes (from bits to bases), i.e. the first entity to have officially crossed the threshold between the analog and the digital 'worlds'. My 'hypervirus' paper—as my piece for *CTheory* was titled (Bardini 2006)—was in fact far from being the first to jump this particular gun. Scott Bukatman had already claimed 'one must further recognize and accept the pervasiveness of the viral trope within postmodernism' (1993: 347).

A few years later, but still ahead of my own 'clinical report', another paper with the same title, from the greatly delirious Nick Land, pretty much made the same point: 'Whatever ultramodernity places under the dominion of signs' he wrote, 'postmodernity subverts with virus. As culture migrates into partial-machines (lacking an autonomous reproductive system) semiotics subsides into virotechnics' (2011: 383).

Now, when Bukatman and Land say 'trope' and mean 'figure', I suggest 'entity'. Some were prompt to correct me, back in 2006: one trope maybe, but definitely two entities that happen to be, by the power of fiction, called by the same name, computer (i.e. digital, in bits) and biological (i.e. analog, in bases) *viruses*. Some implied that it was a *mere* metaphor on my part (since 'mere' always precedes 'metaphor' in their mouth), or even, God forbid, that I was joking. Well, I was not, and today I feel vindicated at last, by the efforts of Craig Venter and his bunch of maverick biologists, computer scientists, and other *bio-informaticians*.

Last July, exactly 70 years after Erwin Schrödinger had delivered his famous lecture at Trinity College in Dublin—the lecture that bootstrapped his book titled *What is Life?*—Craig Venter updated it with an added subtitle: 'A 21st Century Perspective' (Venter 2012). There, in the very same amphitheater, Venter took a mere 40 minutes to officially kick start what he calls 'the digital age of biology', or what I call 'genetic capitalism', aka *Venter capitalism*. He explained

how he and his group of mavericks actually synthetized, allegedly 'from scratch', their first convergent entity. Of course, it was a virus, named PHI X 174. They chose this particular virus, he said, because it is where 'DNA history started'. Venter loves to appear as a pioneer, even at the price of repeating history: PHI X 174 was indeed the first DNA virus ever sequenced, back in 1976, by Fred Sanger and his team. You see, history repeats itself, but with a twist: sequenced first, synthetized second, thus vindicating my confusion between reading/writing and being.

PHI X 174 was not, however, the first virus to be synthetized. In 2002 Eckard Wimmer's group at SUNY Stony Brook succeeded in synthesizing a poliovirus from its chemical code, producing the world's first synthetic biological virus. Rather, PHI X 174 was the first in a series of biological syntheses that would eventually led Craig Venter's team to synthetize 'from scratch' an organism with a minimal genome, a bacterium called *Mycoplasma laboratorium* and nicknamed Synthia, in 2010. Synthia was probably not the first synthetic life form, but it was certainly the first heavily mediatized bioinformatics entity, whose alternate existence as a form of life was acknowledged and even claimed by its creators.

For instance, the acme of Venter's PR job was obvious in his recycling of the practice of 'marking' synthetic entities—Wimmer and his group had initiated this practice in 2002 in inscribing 19 marker genes in their synthetic poliovirus. This however was a standard technical practice designed to allow one to distinguish the synthetic virus from its 'natural' counterparts. Venter and his colleagues, on this other hand, raised it to the next level of public awareness. They transformed the markers into 'watermarks' (their own term), and in an excess of demiurgic hubris, included a few 'messages' significant for humans, insignificant (alas?) for the bacterium, into the sequences of Synthia. They thus wrote the 46 names of the scientists who contributed to the effort, and also a message with an URL. To do so, they developed 'a whole new code where by [they] could write the English language complete with numbers and punctuation in DNA code'.[1] They thus signed their engineered creature, and furnished their philosophy in its very code: a life form and a form of life had eventually merged. This 'philosophy' came in the form of three reverse transcribed quotes that read: 'To live, to err, to recreate life out of life' (James Joyce), 'see things not as they are, but as they might be' (Robert Oppenheimer), and 'what I cannot build, I cannot understand' (Richard Feynman). In fact, they learned later that Feynman rather had once written (on a blackboard), 'what I cannot create, I do not understand', which,

1 Had they studied their art history, these apprentice artists would have noticed that Eduardo Kac had already designed such a language for his *Genesis* piece as early as 1999. See Kac (2007).

Venter (2012) says, 'is a much better quote'. They dutifully rectified this first significant bug, and life thus stood, anew and corrected.

In their very informed and clear keyword entry about the notion of *life form*, Stefan Helmreich and Sophia Roosth show that these two expressions (life form, or life-form, and form of life) both originate as alternate translations in English of the German *Lebensform* (2010: 31). There was thus a time when one could be taken for the other, for instance, when Wilhelm von Humboldt's used *Lebensform* as a synonym for custom, way of life, or even culture. This sense however came to be later translated exclusively in English as 'form of life', in the tradition of Ludwig Wittgenstein's use of *Lebensform*, in his 1953 *Philosophical investigations*, 'to refer to a frame of reference within which linguistic action becomes meaningful' (Helmreich & Roosth 2010: 45). So, I say that in the first 'signed' virus a life form and a form of life converge and merge, I mean that this virus is both 'something living' and a 'frame of reference for linguistic action', nature and culture united through the *medium* of genetic inscription.

Proceeding backward from their achievement into a reading/re/writing of the whole history of molecular biology with some interspersed elements from the history of computing, Venter (2012) boldly albeit logically went to its conclusion: 'Life is code' now, and the (cybernetic) loop was eventually closed. And a new entity is with us to prove it. It is indeed a convergent virus, a virus with a coding twist, *PHI X TWIST*, a synthetic PHI X 174 plus the virtuality of watermarks to come. This small feat did not pass unnoticed but rather created a media frenzy of epic proportions that eventually secured Craig Venter's position as the main figurehead of a new form of capitalism based on creature engineering. The convergence of forms of life and life forms was ready to become a fact of life, and new kinds of creature engineers followed on Venter's foot. As Eckard Wimmer had said from the start, in 2002: 'the world had better be prepared' (Whitehouse 2002).

So now you have it: Synthia, the first entity crossing the digital/analog threshold was born, or rather, claimed Venter in a PR effort worthy of his reputation, 'the first species to have the computer as a parent' (Venter 2012) — besides Katherine Hayles (2005), that is—was synthetized. I was not joking back in 2005, I was merely anticipating the official birth certificate: the first convergent entity exists, and its name is PHI X TWIST. It is both a computer virus and a biological virus. It exists, I say—after Venter—but is it alive? Here again, the answer comes with a twist, because…

Bad Old Viruses Aren't What They Used to Be

At first viruses used to be… well, virulent! This apparent pleonasm was dispelled quite early on, with the discovery (by a French Canadian, among others, if I may add) of the so-called temperate bacteriophages (viruses infecting bacteria and named after Bach's 'Well-Tempered Clavier'), of which the Lambda Phage is the archetypical example. I will not expand on details, suffice to say that these viruses present two etiological modes (of life, more on this later):

- In their *lytic* mode, they are indeed virulent. They replicate inside their bacterial host until they make its membrane explode (this is called *lysis*).
- In their *lysogenic* mode, they insert their genome inside their bacterial host's genome (and are then named 'prophage'). Whenever their host reproduces (by *mitosis*, or cell division), their genome is thus replicated with the bacterial genome.

Let this mind worm dwell in your consciousness for a while, before we go back at it. Before, I need to establish a second point of crucial interest.

Viruses also used to be… semi-living, or half dead; well, not exactly dead or alive, but neither or both (the paradox returns with a vengeance). Calling them dead or alive was, after all, 'a matter of taste,' as was once famously proclaimed by a French man of Nobel authority (Quoted in Villarreal 2004: 105; see also Lwoff 1957). But that changed at the end of the first decade of the new millennium with the discovery of a score of new viruses with nice names (SPUTNIK, MIMI and MAMA viruses), thanks to the work of the French CNRS Research (Centre national de la recherche scientifique, or National Center for Scientific Research) Unit in Emerging and Infectious Tropical Diseases based in Marseille. They found a few new giant viruses—including 'MIMI', which stand for MIcrobe MImicking virus, a virus as big as a bacterium, and, moreover SPUTNIK, a much smaller virus… infecting MIMI. Think about it, a cannibal virus (after all 'phage' comes from the Greek *phagein*, meaning to eat or digest)! That led one of their principal investigators, Jean-Michel Claverie, to proclaim: 'Sure enough, this giant virus is an organism, since it can be sick' (Quoted in La Presse 2008).

Not long ago, biologists could tell us without blushing that nothing was alive under a certain scale, and molecular biology was a kind of oxymoron. An organism was alive, if a metazoan, its organs and cells could be alive too, but at the infra-cellular level, it was pure molecular machines, pumps (in the membrane), batteries and/or engines (mitochondria), reading/writing heads (ribosomes) and even computers of the Turing kind (nucleic acids). What now if viruses—basically elementary nucleic acids, plus a few proteins—are declared to be 'organisms'? One would be tempted to consider that code itself could be

considered alive… making Venter's proclamation work both ways: if life is code (albeit a mere 16,400 Google hits), could code be life? I suspect Venter would not go as far, since there are mavericks, and there are… mavericks.

Now that being said, let us turn back to *lysogeny* and follow it to its end. At the end of this etiological mode, the virus reverts to its lytic mode. The *prophage* is excised from the bacterial genome and further *encapsided*. The *capsid* is a kind of coat of proteins that protects the virus in the wild, outside of its host—when it is called a *virion*. But when the excision is imperfect, the new virions carry within their own genome some bacterial sequences that were close to the original insertion site of the prophage. If these virions infect a new host and enter a new lysogenic mode, they thus introduce these sequences from their first host into the genome of their new host, along with their own genome—if that means anything at all. In other words, they carry over bacterial sequences. Fantastically enough, biologists call this process *transduction*, the same word Gilbert Simondon (2005) uses to refer to the most basic process in his philosophy of *individuation* applying both to life forms and forms of life (respectively vital and psychic individuations in his vocabulary). It is also the most basic process of what Gilles Deleuze and Félix Guattari (1987: 10) used to call *aparallel evolution*. Nowadays, it is called horizontal or lateral genetic transfer (Bushman 2002), but the change of name does not do anything to the strength of their intuition. It is also, by the way, the most basic process of gene transfer used in biotechnologies (aka recombinant DNA).

And this, precisely, is the beginning of my point: transduction should give us the key to this new ontology I called for in my answer to the inaugural question of the seminar. This ontology would in fact be an *ontogenetics*, thus reuniting these two inseparable aspects of a same reality that constitutes a sole process of hetero-organization, according to the fantastic formulation of Jean-Jacques Kupiec (2008). If one enters into the details of Gilbert Simondon's intuition, one could say that viral transduction effectively describes this minimal *internal resonance of the living*, in the very way that viral existence consists exactly in the perpetual relation of the internal *milieu* and the external *milieu* that the individual operates inside itself.

To understand why viral interiority defines this minimal vital interiority one must not confuse the virus with the virion. In Simondonian terms, the virus is exactly the set of all these phases: virions and prophage, encapsided or eclipsed,[2] and none taken independently of the other suffices to characterize a virus as a life

2 This last term is how biologists call this moment of the infection, when the virion inside its host loses its capsid and becomes free code, when the bacterial internal milieu becomes its own internal milieu.

form. If the virus is alive, it is alive through all the phases of its existence, even when it falls out of step with itself [*quand il se déphase*]. Encapsidation and eclipse are the twin processes of the interchange of internal/external *milieu*, when the virus exists in between prophage and virion, in an unperceivable difference [*une difference imperceptible*].

Simondon's transductive doubling means this for the virus: it is both the result and the operator of a primordial transduction (lateral gene transfer). The transductive viral *umwelt*, to speak like von Uexküll,[3] is ambiguous: it is this exact alternation of interior and exterior that the presence or absence of a few proteins cannot summarize. This *umwelt* is relative because these differences of internal/external *milieu*, as well as self/other code are *both* relative. Literally speaking, one could conclude that the notion of the virus's 'own code' does not make sense at all: through transduction, this code might always be some other's code (bacterial or even viral, or otherwise), exactly as its internal *milieu* is alternatively its own (when encapsided) or another's (when eclipsed).

Life itself, at its inferior threshold, at its barest, is this unperceivable difference, this relative difference whence the internal milieu recomposes itself into an external milieu, and vice-versa, whence its own code turns into another. Claude Bernard once famously stated 'life is the result of the contact of an organism and its milieu; we cannot understand life with the organism alone, nor with its milieu alone' (Quoted in Kupiec 2008: 164). The virus as the most rudimentary form of life/life form, is neither autonomous nor dependent, but both, alternatively; it is neither one nor multiple, neither individual virion nor multitude of free codes, colonies or populations, but alternately both. It is the disparate and disparation itself, pure immanence. As the scholastics used to say, it is more and less than one, pure haecceity. And as Muriel Combes comments on Simondon, 'the individual here is pure relation: it exists *between* two colonies, without being integrated into either, and its activity is an activity of amplification of being' (Combes 2013: 24).

So, let me recapitulate all this with help of some recent conclusions of contemporary virology. Once viewed as semi-living or even living-dead entities, molecules or organisms, or both, or neither, viruses are now considered as

3 Zach Blas (2012) contends that von Uexküll's 'premise that things do not have an autonomous existence from the creatures that perceive them' makes it necessary to use 'a second theoretical tool, media theorist Ian Bogost's alien phenomenology, which helps break from this position' (34). For von Uexküll indeed, 'No one, who has the least experience of the Umwelten of animals will ever harbour the idea that objects have an autonomous existence that makes them independent of the subjects' (von Uexküll 2001: 108). Contrary to Blas, I am quite at ease with this position that I also share with Tim Ingold (2011), who first made me notice the confusion between 'object' and 'thing' at work here.

'essential agents within the roots and stem of the tree of life', and their 'very genetic volatility… an essential *precondition* for life' (Villareal & Witzany 2010: 706). To fully understand this paradigmatic dimension, one should probably generalize the viral transduction to all forms of code itself. One should move from the virus to the retrovirus through the intermediate phase of the temperate phage, to the retrotransposons: so many names for the same basic transductive process, for so many etiologies. One should follow the amplification of being in the inversions and their circular causality, the bootstrap loops of code itself, never exactly the same nor another. One should finally understand that nothing essentially distinguishes the nucleic acids of so-called 'superior forms of life' from that of mere viruses. Fluxes of code and capture of codes, *a sole relation runs at all levels of being, in all of its phases*.

Moreover, 'the concomitant discoveries of increasingly host dependent parasitic cellular organisms with a less than minimal genome, and of increasingly complex giant viruses simply using the cytoplasm of their host as a rich medium, suggest that the historical abrupt frontier between the world of viruses and the one of cellular parasites or symbionts might have to give way to a continuous transition' (Claverie & Abergel 2012: 200). This continuous transition recasts significantly the *problématique* of the lower boundary of life and helps us to understand how 'the symbiotic role of viruses in host evolution' can indeed be 'seen to be both major and universal' (Villareal & Ryan 2011: 88). Moreover, as we will now see, the role viruses could play in 'the symbiotic view of life' (Gilbert, Sapp & Tauber 2012) might not be only as key actors in lateral genetic transfers but also in ecological terms strictly. Altogether, viruses can then be understood as the entity of choice to develop a new understanding of life, at a time when synthetic biology is getting ready to give it/them a bright (?) new future. I will now close this loop, and consider the full extent of this convergent life, and carry over the lessons of analog virology to *a critical virology*, analog *and* digital.

Artificial Life Forms, Really

In 1960, a psychologist named J. C. R. Licklider probably changed forever the agenda of computing research in the United States of America. In a groundbreaking paper, he introduced the notion of 'man-computer symbiosis'. I have shown elsewhere (see Bardini 2000: 19–24) how this notion of 'symbiosis' would prove to be very strategic in the context of the management of the U.S. Department of Defense Advanced Research Project Agency Information

Processing Techniques Office (ARPA-IPTO).[4] Here I rather want to stress more the conceptual importance of this paper. Licklider (1960: 4) defined 'symbiosis' in the same way the biologists usually do, as 'the cooperative living together in intimate association, or even close union, of two dissimilar organisms'. To him, this paper 'was largely about ideas for how to get a computer and a person thinking together, sharing, dividing the load—mainly heuristic versus algorithmic' (Aspray and Norberg 1988).

He developed this opposition in a subsequent paper, where he made clear that the former term was usually understood as the dominion of the human, and the latter, of the computer: 'in the general run of computer application today' wrote Licklider, 'the heuristic aspects of problem solving are almost wholly separated from the algorithmic aspects. The heuristic contributions are made by human problem solvers, before their programs get into a computer. Then the heuristic contributions cease abruptly, and the execution of algorithms begins' (Licklider 1965: 19). These two papers were very important in establishing a program of research on interactive computing that Licklider implemented during his tenure at the head of ARPA-IPTO. But they also meant something more profound, that we are just getting to understand fully: through the somewhat metaphorical use of the notions of 'symbiosis' and 'partnership', they effectively allowed us to consider the computer as *a life form*, a partner or symbiotic organism.

The notion of the computer conceived as a *creature*, was in fact not new when Licklider published his two papers in the first half of the 1960s. Numerous attempts to locate culturally the computer inside the tradition of the artificial creature, from the golem to various automata, have been published already. Here I will focus on one in particular, very much in tune with the aim of the present paper: *artificial life* (ALife). In parallel with the inception of the research program in computing known as 'Artificial Intelligence' (AI), devoted to emulating thought in computing machines, the idea of emulating life itself was also present in the mind of some early cyberneticists, starting with John von Neumann. In the early 1950s von Neumann started research in 'cellular automata' in an attempt 'to develop an abstract model of self-reproduction in biology—a topic which had emerged from investigations in cybernetics' (Wolfram 2002: 876). Here again, I will not dwell on a detailed history of the field of ALife, which has been already well covered in the literature (e.g. Levy 1992; Helmreich 1998). For some obvious reasons ALife interests me here, if only because it focuses on the

4 ARPA-IPTO was the most important funding agency for early research on interactive computing in the U.S. during the 1960s. See Norberg and O'Neill (1996). For more on Licklider himself, see Waldrop (2002).

possibility of emulating life not at the level of the computer hardware but rather at the level of software, i.e. Licklider's algorithms.

Among the said algorithms, computer viruses were eventually considered as potential life forms, as concrete, albeit 'immaterial' *realizations* of artificial life: 'many Artificial Life researchers point to computer viruses as evidence of the spontaneous emergence of artificial life' (Helmreich 1998: 129).[5] This claim, however, requires certain precisions. On such precision was given by a researcher whom Helmreich interviewed for his research: '"Life" can only be defined *with respect to a particular physics*. A computer virus is almost "alive" as a real virus (not yet, but close), but only in the physics of the computer memory' (78). Moreover, it seems the whole field got caught in a definitional problem, perhaps best expressed by one of the most cited paper on this debate: 'The first, and obvious, question is "What is life?" Without an answer to this question, we will be unable to say if a computer virus is "alive"' (Spafford 1994). Computer scientists were thus drawn towards the same conundrum that had become quite an *aporia* for many biologists…

In fact, this conundrum existed since the earliest attempts to consider the relative liveliness of computer viruses—or of any other kind of so-called artificial life—and the common method to get out of it appeared to be the description of a set of criteria or 'properties' supposed to characterize life. Such is the case of one of the earliest contributions stemming from the Santa Fe Institute, a site most associated with the emergence of the ALife research field. Following Chris Langton's somewhat tautological inaugural definition of the field as 'the study of man-made systems that exhibit behaviors characteristic of natural living systems' (1989: 1), J. Doyne Farmer and Alletta d'A. Belin (1991) proposed a first set of nine such criteria: (1) pattern in spacetime, (2) self-reproduction, (3) information storage of a self-representation, (4) metabolism, (5) functional interactions with the environment, (6) interdependence of parts, (7) stability under perturbations, (8) ability to evolve, and (9) growth. But they offered this list of criteria reluctantly, after having acknowledged its incompleteness and imprecision, and moreover, after having stated 'there seems to be no single property that characterizes life. Any property that we assign to life is either too broad, so that it characterizes many nonliving systems as well, or too specific, so that we can find

5 John Johnston (2009: 24) remarks 'computer viruses were one of the few topics that Christopher Langton actively sought to discourage at the first ALife conference in 1987'. Johnston also refers to Mitchell Waldrop, who nevertheless added that in one sense computer viruses were 'a natural' to be first considered as Alife: they 'could do almost everything carbon-based life-forms did […] but computer viruses were also dangerous' (Waldrop 1992: 238). Organizing a conference in a U.S. National Laboratory probably made not wanting to 'attract hackers to come to Los Alamos and try to get into the secure computers' (238) a safe idea.

counterexamples that we intuitively feel to be alive, but that do not satisfy it' (818).

In spite of its aporetic nature, the criteria method kept on being used: for instance, Spafford examined the same nine criteria applied to computer viruses, only to conclude that 'our study of computer viruses at first suggests they are close to what we might define as "artificial life". However, upon closer examination, a number of significant deficiencies can be found. These lead us to conclude that computer viruses are not "alive", nor is it possible to refine them so as to make them 'alive' without drastically altering our definition of "life"' (Spafford 1994: 262). Such a 'definition of life' however, has remained at best elusive, even to this day. In a recent paper, Yong Zher Koh and Maurice Ling (2013) have examined no less than 135 definitions of life, spanning the years 1865–2011. Their conclusion, again, left the conundrum intact: 'a computer virus as a digital organism' they wrote, 'can be considered as alive as a bacterium or as alive as a biological virus, depending on the definition'.

It seems that one encounters here what constructivist sociologists of science used to call 'interpretive flexibility', the presence of 'differing interpretations of the natural world' (Pinch & Bijker 1984: 420). What's even more interesting here is that the situation at hand does not only display strong evidence for scientific interpretive flexibility about the definition of life, but also technological interpretive flexibility about the design of 'lively' artifacts. In their founding paper, Pinch and Bijker insist on these two kinds of 'interpretive flexibility' and explain how the second adds to the first: 'not only that there is flexibility in how people think of, or interpret, artefacts, but also that there is flexibility in how artefacts are designed' (421).

Most crucially here, scientific interpretive flexibility then *becomes a resource* for the sustainability of alternative designs, as is evident in this remark from Stefan Helmreich: 'Biologists disagree about whether viruses are alive, and Artificial Life scientists have appropriated this uncertainty to argue about whether computer viruses might not be borderline cases for artificial life. Figuring computer viruses this way allows researchers to claim that there is in fact a threshold to be crossed' (1998: 129). In a more recent paper the same author insisted: 'Artificial Life can be read as a sign of the instability, the limits, of nature as an ontological category. Biology becomes ungrounded. The form of life prepared by belief in these life forms is one in which bioengineering practice can simultaneously lean on 'life' as a category and know that it is constructed' (2011: 683). This paper insists on the notion of 'limit', 'the point at which an identity uncouples from itself, shades or snaps into something else' (684).

Although I understand and value the point Helmreich makes in this paper with such a conceptual tool, I would rather stick to the notion of 'threshold' in his original quote. What is at stake here, again, is not only the differing scientific interpretations of what 'life' actually *is*, but rather the technoscientific interpretive flexibility about how to *design* life forms, a point that Stefan Helmreich and Sofia Roosth make in yet another paper: 'that "life" in this field [synthetic biology] is treated as a coherent entity, despite the fact that what is at stake is its material, attests to the capaciousness of the concept of life form to designate conjectural possibilities that nonetheless stabilize present kinds' (2010: 42).

In an early account of the attempts to synthetize micro-organisms published in *Science*, Dan Ferber noticed how biologists were then wary of this interpretive flexibility: 'Despite many early successes, synthetic biologists might be getting ahead of themselves. Much more needs to be known about the basics of cellular "device physics"—including where proteins are located, how fast they turn over, and what other proteins they talk to, says Eisenstadt. "We'd like to be building life forms from first principles", says Venter, "but it's kind of hard when you don't know all the first principles". And after all is said and done, researchers may never be able to make a synthetic cell at all, Venter says: "People should not accept as a fait accompli that this will work"' (Ferber 2004: 161).

Now, ten years later, people *should* accept that building life forms is a *fait accompli*. The threshold has been crossed, and by none other than the excessively humble—for once—Craig Venter, who else? That, in the meantime, we still do not 'know all the first principles', that still 'much more needs to be known' is, in the end, irrelevant. And *resistance is futile*, as any good SF fan will tell you. This pretty much seems to be the position of some of today's (bio)hackers. Please meet 'Mario', aka 'Second Part To Hell' (SPTH), a contributor and founding member of hh86, 'a female Argentine hacker'[6] who is the editor of the *valhalla* ezine; in other words, a man of many 'handles'. A virus programmer since he was 15 years old, SPTH is a long-time member of the 'virus underground' (see Thompson 2004) which sure knows first-hand that 'building life forms is a *fait accompli*'. In October of 2013, he released on his homepage (and published in *Valhalla* #4 in November 2013) a text that proves it. He wrote:

> Biological life spreads in the biological-chemical world, computer codes can spread in the digital computer world. That is a rule—no self-replicator has ever overcome the digital-biological barrier. Until today. Here I show a

6 'In analogon to Nicolas Bourbaki (the pseudonym of a mathematician collective), together with a few other programmers we sometimes release stuff using the handle "hh86". In order to attrac t more attention, we've defined that pseudonym to be female. ;) Thats [sic] the same concept as "roy g biv"—three or four people behind one pseudonym. Maybe this is an improved concept to a "virus writing group"'(Alcopaul & Brigada Ocho 2011; see also SPTH & DarK CodeZ #5 2013).

> method how a digital computer code can infect biological DNA, thus spread in the biological-chemical world. The method is mainly based on the fantastic research by the J. Craig Venter Institute on synthetic life, and might ask new questions about the definition of life itself (SPTH 2013).

His last entry on the 'main' section of his homepage at the time of the writing of the present paper, dated February 8, 2014, comments on the aftermath of this publication:

> Mikko Hypponen has mentioned my research in infecting biological DNA with digital Computer Code in his talk in Cambridge on 'Silicon Plagues' (see minute 51++). [...] I am a bit worried about the risk of abusing such techniques by criminals, nation states, you name it. Similar as computers are abused and can cause alot of trouble, also synthized DNA can be abused, but obviously on a much more dangerous scale. Compared to that, abusing computers seems like some kiddy games. Per fortuna, yet we are far from the point were synthesizing DNA and booting up bacteria with it is possible on a big scale (Venter compares it with the 40s or 50s of electronic computers). Actually, afaik Craig Venter's lab is the only place where this can be done yet. As a conclusion I think Mikko's statement *'Do not write a computer virus that is able to infect DNA*' is of course true, but a bit too naive. Synthezised DNA has the potential to change our lifes in future tremendously (maybe similar or even more than computers have done), but can (and most likely will) be abused aswell - obviously in a much worse way than computers can ever be. I wonder if somebody is thinking about serios solutions. Those bio-researchers have done some ethical studies, but I don't know how they evaluate the long-term risk. And security-people might be not be interested, as there has not been any accident yet or because the field is too different. Well, maybe it's SciFi after all (SPTH 2013).

Famous last words (in broken English)… so far. So we had better get ready for brand new epidemics. Unless, in accordance with some recent virological theories, what can appear as a maleficent epidemic could in fact hold the key to new forms of evolution, resilience and symbiosis.

Convergent Life and *Suzugia*

In my perspective, a threshold is not a limit, 'a point at which an identity uncouples from itself, shades or snaps into something else' (Helmreich, 2011: 694); it is rather a critical point, in a sense derived from Simondon's ontogenetic model. In this model, Simondon makes use of the notion of 'phase' in the sense of thermodynamics: 'one cannot conceive of a phase except in relation to another or to several other phases,' he writes, only to add, 'in a system of phases there is a relation of equilibrium and of reciprocal tensions; the present system of all the phases taken together is the complete reality' (1989 [1958]: 159). Moreover, he

insists: 'the existence of a plurality of phases defines the reality of a neutral centre of equilibrium in relation to which the phase shift exists'. This notion of 'phase shift' or 'phase transition' is crucial for me to understand what I mean by 'critical point' here. Simondon associates the notion of 'neutral point' to the notion of equilibrium, since 'no phase, as phase, is in equilibrium in relation to itself, nor does it have complete truth or reality: every phase is partial, abstract, and unbalanced; only the system of phases is in equilibrium at its neutral point; its truth and its reality are this neutral point, the procession and conversion in relation to this neutral point' (160). The neutral point is not a phase of being in the world, but rather 'a permanent reminder of the rupture of [a prexisting] unity', extending the existence of this lost unity and thus reaffirming it, when phases 'are in conflict in relation to the neutral point'. Phase shifts, or transitions, only exist in relation to a neutral point of equilibrium, as 'true and balanced relations only exist between phases of the same level [...] in a genetic ensemble balanced around a neutral point, envisaged in its totality' (161). Phases are usually in an 'either/or relation' to each other (they are in conflict, says Simondon), only to converge in an 'and' relation (coexistence) at the neutral point. There is yet another possible relation, of course, when the relation means the disappearance of both phases: it is the so-called 'critical state'.

All this comes from the vocabulary of thermodynamics that Simondon borrows. In the first case, when the phases coexist in an equilibrium point, thermodynamics speak of a first-order phase transition; in the second, when their distinction disappears, of a second-order phase transition. The critical state is a homogeneous thermodynamic state occurring in a second-order phase transition, at a so-called 'critical point' where the distinctive features of the phases gradually disappear. For Simondon, first-order phase transitions only reaffirm a lost unity but are not analogous to it, since at the equilibrium the phases co-exist, and still result from the loss of unity by division (this is, I think, what Helmreich means by 'limit'). Only a critical state, and thus a second-order phase transition, could eventually be analogous to the lost unity, but Simondon does not make mention of it.

So let me rephrase my point: *the threshold between analog and digital life qua viruses is this critical point where digital and analog life eventually appear as phases of life, at a second order phase transition point where their distinctive features disappears and the lost unity of life reappears*.

And this exactly is where Licklider's intuition kicks back and reunites with Margulis' intuition: the lost unity is symbiotic in nature, the lost unity of junk as the principle that binds. Junk is another word for rhizome; the fabric of the rhizome is junk (Bardini 2011). From the metonymical powers invested in junk

and the conjunctive principle that does away with the jerking reflexes of identity at all cost, from within the community of the yoke, or *suzugia,*[7] that binds all life forms, junk rules as an ultraliberal despot would. Junk is, after all, the very image of the reticulated structure of the living world, this ecology of (co)design. From the molecular to the molar, from the earliest somatic plastids and the most rudimentary gemmules, before there was sex or when all there was was sex, undifferentiated and yet differentiating, when sex was proto-sex, intermingling exchange of code, life forces and energy, affects and infects, there was already junk, looming as the archetypical figure of the potential, of this potentiality of the potential (this raising at a higher degree of life, this *potenzirung*, this romanticizing, says Novalis) that we have come to call life. Viruses, be they analog or digital, are the ultimate junk code, the vector princeps of life as code (Bardini 2012).

There you have it. But there might still be a point that needs to be made. How could viruses be considered symbiotic partners? To understand this, one would have to get rid of their most shared connotation, not as vectors of infectious diseases, but rather as vectors of life. I have already alluded to some recent results and theories in virology that seem to go along this direction. Let me expand on them a bit now. I refer here to the work of Luis Villarreal and Frank Ryan:

> A similar complex, multi-faceted contribution of viral symbiosis is increasingly found throughout all the biological disciplines, working at many levels of virus – host interaction, and including both exogenous and endogenous viruses […] At molecular genetics level, it is becoming increasingly established that viruses can have a significant impact on the content and regulation of the chromosomes of host cells. It is possible that viral symbiosis may have contributed to the origins of nuclei, to key enzymes involved in DNA and even whole chromosomal replication […] The potential for future research into viral symbiosis would appear to be considerable. Since virus–host symbioses are universal, such potential will extrapolate to theoretical aspects of evolutionary biology as well as to the practical applications, including medicine, veterinary medicine, agriculture, and ecology (2011: 87–8).

… and computer science. Villarreal and Ryan insist 'Virologists may be skeptical of a symbiotic perspective in what appears to be a situation of outright parasitism'. And so would almost everybody. But they dispel this problem two times: (1) 'A common misconception is to equate symbiosis with mutualism', and (2) the introduction of the concept of 'aggressive symbiosis'.

7 'The Greeks, to express this so solid and nevertheless mute relationship that is the lived sympathy, used, even for the human couple, the word suzugia, community under the yoke' (Simondon 2005: 249).

Referring to yet another definition of 'symbiosis' than the one Licklider used, Anton de Bary's 1878 original definition,[8] they note this definition 'embraced parasitism and commensalism as well as mutualism. All that is required is a living interaction' (Villarreal & Ryan 2011: 80). This first point is purely formal: if it corrects a semantic misconception, it does not explain how the negative connotation (infectious vector) can give way to a more positive conception (vectors of evolution or life). The second point does, but at the price of the introduction of a rather counter-intuitive (or even oxymoronic?) concept, that of *aggressive symbiosis*. This stems from the work of Frank Ryan (1998), who first thought of it while looking for 'virus X'. He later explained it as such:

> When two or more partners enter into a mutualistic symbiosis, each partner will contribute an innate ability, or trait, that the other partner lacks. It is obvious what a host contributes to a virus−host partnership, since it offers the virus shelter and the use of the host's own genetic machinery to make more copies of itself. Without the host the virus would not survive. But although it might appear less obvious, there is in fact a key ability that the virus possesses—in evolutionary terms, a 'trait'—that the host does not. This is the innate potential for lethal aggression (Ryan 2009: 89).

In other words: sure, an infectious virus might eradicate most of a population it infects; but those individuals who survive acquire an evolutionary trait quite valuable: the ability to use the virus aggressiveness to eradicate uninfected individuals, populations or even species that could invade their territory. Talk about unfair competition! Ryan and Villarreal have even described the molecular functioning of such an aggressive symbiosis with yet another counter-intuitive concept: the *addiction module* first introduced by Yarmolinski (See Villarreal 2005:66–9, 166–7). For clarity's sake, I will only give Frank Ryan's somewhat clear explanation of this concept here:

> In essence, the virus deposits a copy of its complete genome inside the body of the bacterium, while keeping the viral genome separate from that of the bacterium in a tiny envelope, known as a plasmid. The viral genome is fully competent—in other words, it is capable of making a complete infectious virus—and hence is known as a 'prophage'. The prophage also codes for two specifically evolved metabolic products, one of which has a long-lived effect that, if unopposed, is lethally toxic to its host, while the second product, the effects of which are short-lived, offers protection against the lethal toxin. From the bacterial point of view, it would be ideal if it could rid itself of the potentially lethal presence of the virus […] But if the bacteria jettisons the plasmid, the anti-toxin effects wear off quickly, while the long-lived toxin is still operative. The bacterium is killed. Not only does this situation results in the death of the host, but the same ferocious virus is also

8 'The living together of differently named organisms' quoted in (Sapp 1994: 7).

> operative in the environment and will kill, through lysis, all bacteria that do not possess the addiction module—in other words, all bacteria that does not contain itself (2009: 188).

A subtle dialectic based on a differential chronological mastery appears to be the key to an aggressive symbiosis. A competitive advantage results from a well-mastered addiction, i.e. from an imbedded and time sensitive *rapport de puissance*. That will provide me with a smooth transition to my conclusion.

Coda Redux: Viral Life, After Theory

'Standing as they do at the border between the "living" and the non-living, and *virtually* real, viruses serve to challenge almost every dogmatic tenet about the logic of life, defying any tidy division of the physical […] into organisms, the inorganic, and engineered artifacts' (Ansell-Pearson 1997).

Keith Ansell-Pearson's intuition dates from the year 1997, but it seems even more prophetic now. During the month of April of the year 2010 of the modern era, a tiny parasite got a new name that would soon become a household icon: an allegedly new strain of the Marpurg virus, first christened Zaire ebolavirus, quite simply became 'the Ebola virus'. In May of that same year, while most civilized human beings seemed to still believe in the exploits of science and technology—administered with a reasonable dose of public relation mastery—a man claimed that he was 'the first human infected with a computer virus'. In the same month of that same year, *Science* reported the creation of a bacterial cell controlled by a chemically synthesized genome (Venter et al. 2010), later introduced as *Synthia*, 'the first species to have the computer as a parent' (Venter 2012). The next month, the Stuxnet computer virus (or worm, depending on the reports) destroyed a large number of centrifuges that were a vital part of Iran's nuclear enrichment process. At the end of the year, as winter approached, Google Flu Trends was found to be 'nearly on par' with the Center for Diseases Control Surveillance Data. This time, *Scientific American* concluded: 'searching for flu symptoms online is a reasonable proxy for actually having them' (Moisse 2010). In 2010, for better or for worse, we lived under the constant threat of the virus, it appears.

The year 2010 was not a particularly special year, however. Radical claims of uniqueness and first occurrences abounded then, but they continue to abound. In fact, they now swarm at the rhythm of viral marketing campaigns, whereby 'viral' itself has become a sign of success. How exactly did that happen? How on Earth could the master villain have become the very emblem of triumph, while at the same time retaining his former status of 'public enemy number one'? I have

argued here that the virus is no metaphor, no coincidence under the same name, but rather a real, actual thing, as alive as you and me; as much alive, but not exactly alive in the same way you and me are alive: *alive, virally*.

Furthermore, I argue that if we want to understand what life is becoming—our, human life, but also life in general—we must take note of what the virus has to teach us. In this sense, I claim, viral life is a model for all lives, however evolved they pretend to be. Put in ontogenetic terms, the virus is the model organism (as biologists would say) for a new ontology absolutely required to make sense of our present—or soon to be present—condition.

As the few aforementioned 2010 instances want to indicate, the virus is such a model organism for our new condition because, it has truly and definitely, passed the threshold that used to separate the analog from the digital, or as everybody errs to think these days, the 'virtual worlds' from the material world. There is, of course, only one world and it is and always will be, as it has always been, both material and immaterial, continuous and discreet, analog and digital. The illusion of separation into distinct realms of what are, after all, only *modalities* or *modes of existence* within the same, one and only world, is the first illusion to dispel. It used to be a matter of principle—or a philosophical point of contention—it is now in evidence.

What is a virus, but a minimal life form? A virus is basically a piece of code (be it DNA or RNA), only able to protect itself through the synthesis of a few proteins, and invade a host through the synthesis of some other proteins. What does it mean then, if (some) biologists now say that viruses are alive? DNA barely exists as such anyways, except as a laboratory artifact. In nature, it exists under the form of chromatin, where the nucleic acid is intrinsically bounded with histone proteins. In other words, in biology too, as Friedrich Kittler once said, *there is no software*, or more accurately, 'software does not exist as a machine-independent faculty' (Kittler 1995). And this machine metaphor makes even more sense when one considers the convergence of the analog and digital modalities of the contemporary existence of the virus. The dual archeology of the virus—both as computer virus and biological virus—has reached a turning point, and everything it entails has to be reconsidered upside down. The archeology of the virus as a form of life (computer code) has to be completed and reevaluated with the help of the archeology of the virus as a life form (infectious agent of life and death): at the very moment when both merge, a new condition emerges.

Hence, I repeat: the virus is, *in all of its modalities*, should be considered alive. Both biological and computer viruses, and everything that stands in between as a hybrid, a symbiosis, or whatever that might bind them, should be considered alive. *Viral life, at last*.

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